RESEARCH PAPER

A Retrospective Cohort Analysis of Robotic Stapler Use in Robotic-Assisted Donor Nephrectomy

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Main Problem: Robotic-assisted techniques are common for living-donor nephrectomy. While robotic stapling offers increased surgeon control, there is limited comparative data versus laparoscopic linear stapler use for ligation of renal vessels. Methods: We retrospectively reviewed 32 consecutive robotic-assisted donor nephrectomies by a single surgeon for perioperative outcomes. Results: Patients in the robotic stapler (RS; n = 20) and laparoscopic stapler (LS; n = 12) groups were comparable in terms of age and BMI. Estimated blood loss (p = 0.62), warm ischemia time (p = 0.50), and console time (p = 0.56) were similar between the RS and LS groups. There were no stapler misfires or major intraoperative complications in either group and no cases required conversion to open. Conclusions: Robotic stapler use is safe and effective in robotic-assisted donor nephrectomy, even in cases of complex renal hilar anatomy. Further research on prevalence of robotic stapler use is needed to quantify the associated complication rate.

donor nephrectomy | robotic surgery | robotic stapling

Renal transplantation is the preferred form of renal replacement therapy for patients with end stage renal disease (1). Recipients of living donor renal transplants have superior graft survival as compared to deceased donor transplants (2). This requires the exposure of altruistic, healthy donors to the potential morbidity of surgery. The mortality rate of living donor nephrectomy has been reported as 0.02% to 0.04% [3], with a complication rate of approximately 3 to 30% (4,5). Potential early postoperative complications include the need for blood transfusion, hospital readmission, and the need for interventional procedures or reoperation (5).

Advancements in medical technology have brought changes to donor nephrectomy techniques, with cases transitioning from an open to laparoscopic, and now robotic-assisted approaches. Robotic-assisted donor nephrectomy (RADN) has been shown to be safe and effective. A 2019 systematic review of RADN involving 18 studies and 910 patients determined an early postoperative complication rate of 0 -15.7% with no reported donor mortality (6). The development of the robotic-controlled surgical stapler (Intuitive Surgical, Sunnyvale, CA, USA), released for the da Vinci® Xi™ in 2014, is another advancement that has been applied to the transplant field and used in donor nephrectomies (7).

Traditional methods for hilar control in these cases have been laparoscopic clipping or stapling. However, there is a risk of clip slippage or stapler misfire, respectively, with these techniques (8). Endovascular GIA stapler malfunction was reported in 1.7% of cases in a series of laparoscopic nephrectomies (9). Little is known about the types and incidence of adverse surgical events associated with the use of a robotic stapler, however. Moreover, staple line failure can result in significant postoperative morbidity in the case of anastomotic leak or staple line bleeding. To begin to answer this question, we performed a retrospective comparative analysis of robotic-assisted donor nephrectomies at our institution performed with and without the robotic stapler.

Material and Methods

Thirty-two consecutive robotic-assisted donor nephrectomies by a single surgeon were retrospectively reviewed. The study was approved by the Institutional Review Board at the authors'

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institution (University of Toledo Institutional Review Board, Reference 300350-UT). Cases were stratified by the technique used to secure the renal vessels: robotic with robotic stapling (RS) or robotic with handheld laparoscopic stapling (LS). The da Vinci SureForm™ stapler (Intuitive Surgical, Sunnyvale, CA, USA) with 45 mm loads was used for robotic cases. Endo GIA™ stapler (Covidien/Medtronic, Minneapolis, MN, USA) was used for RS cases. Before stapling, each renal artery and vein were dissected circumferentially to the level of insertion at the aorta and inferior vena cava, respectively. In each case, a single vascular load was used for taking each vessel. Multiple stapler loads were used in cases of vascular multiplicity.

Relevant variables were abstracted from medical records for each case including estimated blood loss (EBL), length of stay (LOS), warm ischemia time (WIT), and robotic console times. EBL was estimated by the surgeon in collaboration with the anesthesia team. When there was disagreement between the operative report dictation by the surgeon and the operating room charting in the medical record, the EBL value from the medical record was used. LOS was calculated as the difference from the date of surgery to the date of discharge, rounded to the nearest whole day. WIT was computed from the charted time of renal artery stapling to the charted time the graft was placed on ice. Robotic console time was computed as the time from robotic docking to robotic undocking, as charted in the medical record by the circulating nurse. All variables were compared using two-tailed Mann-Whitney U tests with level of significance 0.05.

Table 1. Patient demographics for 32 consecutive patients undergoing LADN, stratified by type of endovascular stapler (robotic stapler, RS, or laparoscopic linear stapler, LS) used for division of the renal hilar vessels.

Patient Demographics		**RS**	**LS**
Variables	Categories	n = 20	n = 12
Sex			
	Male	7	4
	Female	13	8
Race			
	Caucasian	16	10
	Hispanic	2	0
	Middle Eastern	1	0
	Asian	0	2
	Other	1	0
Age			
	<45	5	6
	45-60	11	4
	>60	4	2
BMI			
	<25	2	2
	25-29	12	6
	>30	6	4
Pre-operative anatomy			
	Single Renal Artery	19	10
	Multiple Renal Arteries	2	2
	Single Renal Vein	18	10
	Multiple Renal Veins	3	2

Results

A single surgeon performed all included RADN cases (n = 32). Twenty cases (62.5%) were completed using the robotic stapler and 12 (37.5%) using the laparoscopic stapler. Both groups were predominantly female (65% and 67%, respectively). The groups were comparable in terms of age (47.4 vs. 45.7 years; p = 0.47) and BMI (28.3 vs. 27.9 kg/m2; p = 0.92). The majority of the patients in the RS group had a single renal vein and artery, while 5/20 (25%) of patients had vascular multiplicity. The majority (10/12; 83.3%) of the LS group had a single renal vein and artery, with 2/12 patients (16.7%) having multiple arteries and veins. Results are summarized in Table 1.

The mean WIT was similar between groups at 7.11 and 7.78 minutes for RS and LS groups, respectively (p = 0.50). Mean EBL was slightly lower in the RS group at 57 mL (range 5-225 mL) compared to 82 mL (range 10-300 mL) in the LS group, but this difference was not statistically significant (p = 0.62). Length of stay for RS cases ranged from 1 to 3 days with a mean of 1.7 days and in LS cases ranged from 1 to 3 days with a mean of 1.6 days (p = 0.58). Both left (RS: n = 18 (90%), LS: n = 8 (66.7%)) and right (RS: n = 2, LS: n = 4) donor nephrectomies were performed in each group.

Robotic console time for RS cases ranged from 142 to 288 minutes with a mean of 209.6 minutes. In LS cases, robotic console time ranged from 144 to 294 minutes with a mean of 206.1 minutes (p = 0.56). Case details are summarized in Table 2.

There were no major intraoperative complications or stapler misfires in either group. No cases required conversion to open. Sufficient length on both the renal artery and vein were obtained in all cases to successfully complete living donor renal transplantation. There were no Clavien grade II or greater complication in the RS group and one in the LS group that was not related to stapler use, a ventral incisional hernia of the extraction site that required elective outpatient repair (Clavien IIIb).

There were two Clavien I complications in the RS group (post-operative nausea and post-operative ileus), and four Clavien I complications in the LS group: three cases of post-operative nausea and one patient with post-operative urinary retention. The change in donor creatinine from preoperative visit to one-week postoperative visit was not significantly different (-0.46 for RS vs. -0.42 for LS; p = 0.13).

Table 2. Case variables: Mean outcomes and p-values for relevant case variables for both groups.

Variable	**RS**	**LS**	**P-value**
Warm ischemia time (minutes)	7.11	7.78	0.50
Estimated blood loss (mL)	57	82	0.62
Length of stay (days)	1.7	1.6	0.58
Robotic console time (minutes)	209.6	206.1	0.56

Discussion

Upon retrospective review of 32 consecutive RADN cases, we found that patient outcomes were comparable in terms of robotic console operating time, EBL, and WIT. There were few complications in our series, with one incisional hernia in the handheld stapler group that presented several weeks after the procedure, and none in the robotic stapling group. Prior retrospective studies have confirmed the safety of RADN as compared to laparoscopic donor nephrectomy (10,11). We previously published our initial case series of ten patients that underwent RADN with robotic stapler use (7). Here we report a total of 20 robotic stapler uses in donor nephrectomy cases without major complication. In this retrospective cohort analysis, we noted comparable outcomes with respect to EBL, WIT, and robotic console time.

To our knowledge, there are no other retrospective comparative studies for robotic stapler use in donor nephrectomies or urologic surgery. A retrospective case-matched analysis for Roux-en-Y gastric bypass bariatric procedures demonstrated increased cost and more stapler reloads needed for cases where a RS was used (12). The RS group trended towards increased operative time, but this difference was not statistically significant. The slightly longer RS operative times may have been due to the learning curve associated with a new technology on both the part of the console surgery and the operating room staff. Operative times were not significantly different between groups in our cohort.

In the aforementioned gastric bypass analysis, there was one RS-related complication, and none in the LS group (12). Another retrospective analyses noted similar operative outcomes for RS use in colorectal surgery with respect to EBL, operating time, LOS, and complications (13). A 2019 systematic review of operative outcomes of robotic surgical procedures performed with laparoscopic linear staples or robotic staplers concluded very little perioperative data is available on the use of laparoscopic versus robotic staplers (14). We hope that our retrospective comparison of our RS and LS outcomes for living-donor nephrectomies contributes to this important topic.

Our study had several shortcomings common to many retrospective comparative analyses. Data were for a single institution and surgeon and therefore may be impacted by local surgical practices and variations. Our groups were not randomized and thus may be subject to selection bias by the surgeon in terms of which stapling modality was used. It should be noted, however, that the RS group was actually more vascularly complex, with 25% of the 20 cases having renal hilar vascular multiplicity. As with any retrospective study, there may be errors in reporting of WIT or robotic console time on the part of the operating room staff. These variables were abstracted from the medical record and not collected prospectively. LOS data was rounded to the whole number day due to inherent limitations in the charted discharge time in the medical record.

Conclusion

Overall, our comparative data agree with our previous report that robotic stapler use for RADN is safe and feasible, with comparable perioperative outcomes at our center to cases in which a laparoscopic linear stapler was used. Additional prospective studies are needed to validate these findings.

Conflict of interest

Authors declare no conflict of interest.

Institutional Review Board approval

All procedures performed involving human participants were in accordance with the ethical standards of the institutional research committee (University of Toledo Institutional Review Board, Reference 300350-UT).

Authors' contributions

ZCG: Study concept and design, project development, data collection, data analysis, manuscript writing; AE: Data collection, manuscript writing OE: Study concept and design, project development, manuscript editing and revision of content. All authors wrote the manuscript, read and approved the final document.

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